FACCE-MACSUR

Identification of most important cropping systems and available models

Task leader: Marco Bindi[1]* (P62)
Partner involved:
Norwegian Institute of Agricultural and Environmental Research, Bioforsk (P 128)
Leibniz-Zentrum fuer Agrarlandschaftsforschung (ZALF) (P 147)
Scottish Agricultural College (P 47)
Wagenigen University and Research Centre (P 195)
University of Sassari (P 62)
Institute of Soil Science and Plant Cultivation- Research Institute Pulawy (P 125)
Technical University of Madrid (24)
Institut National de la Recherche Agronomique, INRA (P 175/188/169/196/206/201)
Swedish University of Agricultural Sciences and Lund University (P 163/94)
Global Change Research Centre, Academy of Sciences of the Czech Republic (P 17)
Copenhagen University (P 73)
MTT Agrifood Research Finland, Mikkeli, Agrosystems Modelling Group (P 92)
Aarhus University (P 189)
Institute of Bio- and Geoscience (P 159)
Rothamsted Research (P 25/65)
University of Bonn (P 115)
Ulg-Gembloux Agro-Bio Tech (P 151)
University of Natural Resources and Life Sciences, BOKU (P 208)
Karlsruhe Institute of Technology (P 101)
Université de Liège – Arlon Campus Environnmenent (P 51)
Aberdeen University (P 117)
Potsdam Institute for Climate Impact Research (P 83)

[1] University of Florence, Piazzale delle Cascine 18, IT50144 Florence, Italy

*marco.bindi@unifi.it

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Abstract

For each region or agro-ecological zone in Europe the major cropping systems have been identified based on their cropping area. Next, for each of the selected cropping systems the most widely applied models that fulfil a number of criteria (including their documentation in peer reviewed publications; good user guides and documentation of code; source code available) have been identified. Some possible model comparisons have been hypothesized on the basis of cropping systems and model availability.

Table of Contents

Introduction

When the research community is dealing with the assessment of climate change risks, adaptation and mitigation measures for the various sectors, key questions are very often related to whether and to what extent the available crop simulation models are able to reproduce properly climate change impacts and evaluate the appropriateness of suggested adaptation and mitigation measures. To this end, proper model inter-comparison studies may represent a fundamental step for a correct application of these tools in climate change impact assessment (Palosuo et al., 2011; Rötter et al. 2012). Comparison of different modelling approaches and models can reveal the uncertainties involved. Variation of model results in model inter-comparisons involves also the uncertainty related to model structure, which is probably the most important source of uncertainty and most difficult to quantify.

The first step of a model inter-comparison study is the selection of the crops or cropping systems and an evaluation of the available crop models. Thus, the aim of Task C1.1 was: i) to identify for each region or agro-ecological zone in Europe the major cultivated crops or cropping systems; ii) to collect all the crop models that will be made available by the CropM partners for the model inter-comparison; iii) to hypothesize possible model inter-comparison studies on the basis of the information collected in the two previous points.

Methods

In order to identify the major cultivated crops/cropping systems and know the crop models that will be made available for CROPM, a survey has been conducted among the partners. In particular, the following information/opinions have been requested:

- ***Selection of crops/cropping systems***. For selecting the main crops/cropping systems in Europe, it was asked:
    - at which level of aggregation the information should be analysed (e.g. the 4 parts of FAOSTAT database; the EEA biogeographical areas; the NUTS administrative levels)
    - how to select crops (e.g. single crop or cropping systems; on the basis of their cultivated area or economic contribution)
- ***Crop models available***. At all the partners it was asked to provide information on the crop models that they will make available for CROPM studies (e.g. name and acronym of the model, simulated crop or cropping systems, references, input and output parameters)

The results of this survey is reported in two Excel files loaded at the Macsur web site http://macsur.eu/index.php/internal-documents/CropM/

Results

Selection of cropping systems

On the basis of the results of the survey, it was decided to check the FAOSTAT and the EUROSTAT databases to collect information on crops and cropping systems. It has been decided to use the two databases to have a full cover of crops and cropping systems for the whole Europe. In particular, the information collected from the two databases was organised aggregating the cultivated areas for single crop or cropping systems, and for different spatial units (i.e. country, the 4 Europe parts of FAOSTAT database; the Europe EEA biogeographical areas) (Tables 1-6 from Eurostat; Tables 7-12 from FAOSTAT).

For both databases the reference period was 2006-2011 and the data on cultivated areas were collected at NUTS2 (EUROSTAT) and country level (FAOSTAT), respectively. For the EUROSTAT the data come from 32 countries (EU 27, plus Bosnia-Herzegovina, Croatia, Iceland, Macedonia, Turkey); while for FAOSTAT database the data come from 40 countries (including also Russian Federation). The data were then aggregated for different cropping systems and spatial units. The main differences between the two databases were: i) number of countries (32 and 40); ii) number of crops/cropping systems that may be selected (higher in the EUROSTAT); iii) data availability (e.g. from Eurostat the data from a few countries were not available for this reference period, Greece, Norway, Slovakia).

Crop models available

As reported in Table 13 within CropM a large range of crop and cropping systems may be simulated and studied. In particular, the available crop models will allow to simulate crops ranging from perennial grass to fruit trees (e.g. grapevine and olive), through arable crops (cereals, tuber crops, industrial crops, no food crops, etc.). Moreover, cropping systems may be simulated including different crop and soil managements (e.g. rotation, fertilisation, irrigation, etc.). For several crops or cropping systems it will be also possible to carry out model inter-comparisons (at least two different crop models).

Further, the same crop model will be made available from different partners (Tab. 14), this may allow to investigate how models setup, calibration and validation may affect model outputs.

Finally, a pedigree and a map of the evolution of crop models will be possible for understanding why models behave similarly or differently.

Discussion

On the basis of the information reported on the tables and following a discussion between WP1 and WP2 leaders, a preliminary hypothesis of crop model inter-comparison has been formulated. This hypothesis takes into account the models that are available within CropM, the work that has already been done within other projects (COST734, AgMip), with the aim to analyse new items such as typical European crops (durum wheat, sunflower, oilseed rape, forage maize), crop managements (rotation, fertilisation level and distribution) and crop and soil parameters (total biomass, nitrogen yield, soil water, nitrogen and carbon, N leaching).

This work will be finalised with a scientific paper analysing the applicability of the crop models available within CropM in CC impact or adaptation studies. More than 50 crop models are made available from CropM partners. These represent almost all the crop models that usually are used in CC impact studies, but at the same time these models have many limits in terms of their capacity to simulate extreme events, yield quality, crop management options (rotation, irrigation, fertilisation, cultivars). Thus, the idea is to produce a paper that describe the pros and cons of the models in CC impact and adaptation assessments.

Title: Are current crop models appropriated for CC impact or adaptation studies: strengths and weaknesses ?
Authors: M. Bindi, C. Kersebaum, + one author for each partner/crop model
Journal: Multi-disciplinary Journal or Agricultural Journal (e.g. European Journal of Agronomy)
Deadline: first draft by July 2013

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Table 1. Crop harvested areas at country level (average on 2006-2011)[i].

	CROP HARVESTED AREA (1000 Ha)																	
COUNTRY	**Barley**	**Cereals (exl. Rice)**	**Green maize**	**Grain maize**	**Oil seed**	**Olive**	**Potatoes**	**Pulses**	**Rape**	**Rice**	**Rye**	**Fruit**	**Soy bean**	**Sugar beet**	**Sunflower**	**Tobacco**	**Vineyards**	**Common Wheat**	**Durum Wheat**
Austria	181.5	813.9	80.5	197.8	126		22.4	29.1	51.9		43.8	0.5	26.9	43.3	27.5		44.7	282	16.5
Belgium	48.2	338	170.4	62.3	10.2		72.6	2	10.5		0.6	10.6		70.2		0.1		212.9	
Bulgaria	217.4	1716.1	34.9	244.3	725		16.6	7.9	151.4	9.7	7.6	1.6	0.5	0.7	690.8	26	110.9	1095.6	23.4
Cyprus	37.1	48.3	0.2		0.2	15	4.5	0.9								0.1	9.3	7.4	7.5
Croazia	50.4	544.9	29.8				10.9	2.1	17				57.7	22.8	28.2	5		157	2.2
Czech Republic	405.3	1490.1	181.5	91.6	486.5		27.4	27.5	365.7		38.5	1.4	7.7	55.7	27.1		16.7	842.7	
Denmark	633.2	1484.9	160.1		160.3		39.9	7.6	159.5		32.8	4.2		39.1				710.5	
Estonia	111.6	286.2	1.9				7.7	7.9	93.6									123.9	
Finland	526.7	1121.7			88		26.3	8.1	98.4		23.4	2.9		16.2				216.2	
France	1683.2	9051.5	1351.3	1517.2	2153.2	19.8	158.2	280.4	1512.1	17.3	27.1	1449.7	39	386.2	582.2	1450.1	877.9	4788.1	454.3
Germany	1769.8	6760.7	1767.8	492.4	1506.8		259.1	93.7	1407.9		743.2	4.7		378.8	25.1	2.8	99.9	3232.8	13.5
Greece																			
Hungary	301.1	2775.1	98.9	1165.7	808.4		22.9	21.2	228	2.5	40.6	7.7	34.7	23.4	535.5	6	83.4	1064.4	10.8
Ireland	176.2	289.1	20.7		6.6		11.8	3.3	6.6					1.7				88.6	
Italy	304.8	3421.8	282.9	1080.9	294.4	1164.6	66.6	74.7	12.5	549.6	2.9	0.6	158	88.4	122.4	28.1	784.2	581	1314.7
Latvia	116.8	514.9	7.2		84.8		25.9	2.6	102.4		42.8	13.7		12.7				274.4	
Lithuania	316.4	1013	20.4	5	163.2		46.2	43.1	197.8		65.1	8.5	0.4	15.4				434.1	
Luxembourg	8.6	29.1	12.7	0.3	4.8		0.6	0.3	4.7		1.1						1.4	13.5	
Macedonia	40.4	124.3					6.5											78.1	
Malta							0.7												
Netherlands	42.1	224.2	229.9	23.7	4.7		156.1	2.9	2.8		2.5	1.5		75.5	0.2			149.1	
Norway																			
Poland	1134.9	8226.1	396.7	289.1	777.1		491	138.5	796.3		1356.6	74.2	0.2	217.8	3.1	16.7	0.3	2218.7	
Portugal	31.7	290.6	94.3	103.4	18.5	381.6	34.1	10.4		28.4	21.9	0.0		1.4	18.9	0.4	220.9	60.3	4.3
Romania	422.7	5141.7	36.5	2433.5	1282.8		258.7	55	362.8	10.4	14.5	87	93	25.1	864.4	1.3	189.4	2052.1	5.4
Slovakia																			
Slovenia	18.5	98	26.3	40.8	8.6	0.9	4.7	1.8	4.5		0.8		0.1	3.4	0.2		16.2	32.6	
Spain	2927.8	5769.9	96	344.4	628.7	2483.7	81.5	431.6	19.4	117	106	10	0.7	57.9	722.6	10.3	1135.2	1586.8	410.6
Sweden	337	982.2	14.3	1.3	104.5		27.6	27.7	95.3		27.2			39.8				377.9	
Turchia	2869	11804	12				145	778	27	99			26	297	656	97		6762	1338
United Kingdom	945.5	3044	157				142	182.5	673.5					115.5				1954	

Table 2. Cropping systems land use at country level (average on 2006-2011).

LAND USE (1000 Ha)										
COUNTRY	**Arable land**	**Permanent crops**	**Cereals (excl. Rice)**	**Rice**	**Pulses (dried)**	**Root crops**	**Industrial crops**	**Vegetables**	**Fruit trees**	**Grassland**
Austria	1374.4	66.8	818.1		22.9	67.6	148.9	14		1726.6
Belgium	839.8	21.4	342.1		1.9	143	31.7	40.6	16.7	507.6
Bosnia-Herzegovina	485		295.8		11.2	46.8	5.6			
Bulgaria	3142.5	170.8	1795.3	10.7	7.5	15	1012.2	26.1	155.6	1733.5
Croatia	884.9	85	574.6		2.8	38.2	121.3	10.7	84.5	345
Cyprus	101.4	36	34.3		0.7	5		2.6	28.5	2.3
Czech Republic	2593.9	40	1485.2		27.5	84.1	496	9.4	39	915.3
Denmark	2454.7	9	1487.8		8.3	83.2	160.3	11.9	6.9	216.4
Estonia	595.9	4.9	296.2		6.9	7.2	90.9	2.5	2.6	366.7
Finland	2248.8	4.2	1106.2		12.2	40.6	134.3	12		32.9
France	19226.9	1094.6	9343.4	24	116.2	287.9	1416.8	221.2		9929.7
Germany	11899.4	200.2	6668.1		93.7	646.8	1498.3	121	162.6	4748.4
Greece	1891.8	1152.4	989.3		23		336.3	111.3		166.1
Hungary	4451.8	191.1	2791.9	2.7	21.6	36.4	882.2	78.5	99.8	960.4
Iceland	34		4.2				0.1	0.2		1557
Ireland	1107.5	2.5	288.2		3.7	25.3	11.7	4.7	1.6	3221.5
Italy	7509.9	2529.7	3198.3	238.5	73.0	128.9	280.7			3540.2
Latvia	1134.1	9.6	536.3		3	30.8	112.1	8.6	5.9	637.1
Lithuania	1927.3	31.8	1073.4		49.6	58.9	251.9	14.2	29.1	767.9
Luxembourg	61.2	1.5	29.6		0.3	0.6	5			67.2
Macedonia	429.2	36.1	163.4	3.7	5.9	14.2	24	48.1		630
Malta	8.7	1.2				0.7		1.8		
Netherlands	1022.2	35.3	220.5		3	229.7	10.9	77.8	13.1	804.7
Poland	11845.9	360.3	8007.8		153.1	727.6	931.1	199.8	345.2	3272.3
Portugal	1204.7	749.8	274.3	28.8	13.1	28.3	19.6	42.9		1736.2
Romania	9075	382.3	5164.8	12.9	44.4	289.1	1396.2	172.6	154.9	4623.4
Slovakia	1354.7	24.3	740		10.7	29.3	272.8	10.5	14.3	523.7
Slovenia	175.1	27	96.1		1	4.4	12.1	3.1	25.8	284.5
Spain	12700.9	4723.1	5940.4	119.2	429.5	183.6	928.2	350.3	4681.1	6610.8
Sweden	2628.9	2.9	990.4		31.2	66.4	116	18.3		468.3
Turkey	22194.8	2906.4	11804	99	778		774	821	3091	14617
United Kingdom	6236.8	39.1	3054.7		197.7	293.5	678	130.0	15.5	10867
TOT. E.U	132842.1	14939.1	69614.6	539.5	2153.5	3612.8	12159.3	2565.6	8973.7	75879.7

Table 3. Crop harvested areas for the 4 FAO European areas (average on 2006-2011)[ii].

CROP HARVESTED AREA (1000 Ha)																			
EUROPE AREA	**Barley**	**Cereals (exl. Rice)**	**Green maize**	**Grain maize**	**Oil Seed**	**Olive**	**Potato**	**Pulses**	**Rape**	**Rice**	**Rye**	**Soft fruit**	**Soy bean**	**Sugar beet**	**Sunflower**	**Tobacco**	**Vineyards**	**Common Wheat**	**Durum Wheat**
Northern Europe	3163.3	8735.8	381.6	6.3	607.4		327.3	282.7	1427.1		191.2	29.2	0.4	240.4				4179.7	
Southern Europe	3410.8	10297.9	529.5	1569.5	950.3	4045.7	209.6	521.4	53.3	695.0	131.6	10.6	216.4	173.9	892.4	43.8	2165.8	2503	1739.2
Western Europe	3733.4	17217.3	3612.5	2293.7	3805.6	19.8	669	408.3	2989.8	17.3	818.2	1466.9	65.9	954.1	635	1453	1023.9	8678	484.3
Eastern Europe	5350.5	31153.1	760.5	4224.2	4079.8		961.6	1028.1	1931.3	121.5	1457.7	171.9	162.0	619.7	2776.9	147	400.6	14035.5	1377.6
TOT.E.U	15658	67404.2	5284.2	8093.6	9443.1	4065.5	2167.5	2240.6	6401.5	833.8	2598.6	1678.5	444.7	1988	4304.3	1643.8	3590.2	29396.7	3601.1

Table 4. Cropping systems land use for the 4 FAO European areas (average on 2006-2011).

LAND USE (1000 Ha)										
EUROPE AREA	**Arable land**	**Permanent crops**	**Cereals (excl. Rice)**	**Rice**	**Pulses (dried)**	**Root crops**	**Industrial crops**	**Vegetables**	**Fruit trees**	**Grassland**
Northern Europe	18367.9	104	8837.5		312.6	605.8	1555.2	202.4	61.6	18134.7
Southern Europe	25391.6	9340.2	11566.4	390.2	560.1	450	1727.8	570.8	4819.9	13315.1
Western Europe	34424	1419.8	17421.7	24	238	1375.7	3111.7	474.6	192.4	17784.3
Eastern Europe	54658.5	4075.1	31789	125.3	1042.8	1181.3	5764.6	1317.8	3899.8	26645.6
TOT. E.U	132842.1	14939.1	69614.6	539.5	2153.5	3612.8	12159.3	2565.6	8973.7	75879.7

Table 5. Crop harvested areas for regions defined by the EEA biogeographic classification (average on 2006-2011)[iii].

	CROP HARVESTED AREA (1000 Ha)																	
BIOGEO. CLASS	**Barley**	**Cereals (exl. Rice)**	**Green maize**	**Grain maize**	**Oil seed**	**Olive**	**Potatoes**	**Pulses**	**Rape**	**Rice**	**Rye**	**Soft fruit**	**Soy bean**	**Sugar beet**	**Sunflower**	**Tobacco**	**Vineyards**	**Common Wheat**	**Durum Wheat**
Atlantic	3528.4	14431.5	2089.4	1603.1	2334.9	19.8	580.5	478.6	2364.9	17.3	62.8	1466	39	688.3	582.4	1450.2	877.9	7903.2	454.3
Continental	4328.7	26781.8	2585.1	4757.6	5600	0.9	1091.9	348.1	3338.4	22.5	2202.7	176.5	193.8	727.6	2174.4	57.8	518.1	7854.7	50.9
Mediterranean	3341.8	9655	473.4	1528.7	941.7	4044.9	194	517.5	31.9	695	130.8	10.6	158.7	147.7	864	39	2149.6	2314	1737
Boreal	1408.5	3917.9	43.8	6.3	440.5		133.7	89.3	587.5		158.5	25	0.4	84.1				1426.5	
Alpine	181.5	813.9	80.5	197.8	126		22.4	29.1	51.9		43.8	0.5	26.9	43.3	27.5	0.0	44.7		
Anatolian	2869	11804	12				145	778	27	99			26	297	656	97		6762	1338
TOT.E.U	15658	67404.2	5284.2	8093.6	9443.1	4065.5	2167.5	2240.6	6401.5	833.8	2598.6	1678.5	444.7	1988	4304.3	1643.8	3590.2	26260	3580.1

Table 6. Cropping systems Land use for regions defined by the EEA biogeographic classification (average on 2006-2011).

	LAND USE (1000 Ha)									
BIOGEO. CLASS	**Arable land**	**Permanent crops**	**Cereals (excl. Rice)**	**Rice**	**Pulses (dried)**	**Root crops**	**Industrial crops**	**Vegetables**	**Fruit trees**	**Grassland**
Atlantic	30887.9	1202	14736.6	24	330.8	1062.6	2309.3	486.3	53.8	25546.9
Continental	45969.5	1482.5	27649.3	26.3	373.9	1918	6633	631.6	1081.7	17473.7
Mediterranean	23847	9228.2	10599.9	390	545	360.6	1588.8	557.1	4709.6	12685.6
Boreal	8535	53.4	4003		102.9	203.9	705.2	55.6	37.6	2272.8
Alpine	1374.4	67	818.1		22.9	67.6	148.9	14		1726.6
Anatolian	22194.8	2906.4	11804	99.0	778		774	821	3091	14617
Artic	34		4.2				0.1	0.2		1557
TOT.E.U	132808.1	14939.1	69610.4	539.5	2153.5	3612.8	12159.2	2565.5	8973.7	74322.7

Table 7. Crop harvested areas at country level (average on 2006-2011)[iv].

COUNTRY	AREA HARVESTED (1000 Ha)															
	Barley	**Grapes**	**Green Maize**	**Maize**	**Oats**	**Oilseeds Nes**	**Olives**	**Potatoes**	**Pulse**	**Rapeseed**	**Rice paddy**	**Rye**	**Soybeans**	**Sugar beet**	**Sunflower**	**Wheat**
Albania	2.0	8.1		52.8	13.4		38.3	9.3	1.0			1.3	0.3	2.0	1.5	75.8
Austria	211.8	44.4	0.7	169.4	28.5	23.0		22.4	2.5	51.9		44.5	26.9	43.3	27.5	298.4
Belarus	655.4	1.3		108.3	190.2			389.0	0.2	255.3		454.0		95.7	12.5	524.1
Belgium	48.6	0.0		63.8	4.9			72.8		10.2		0.5		69.0		204.1
Bosnia and Herz.	21.1	5.4	0.1	195.2	13.5		0.1	38.7		0.9		3.5	4.6		0.3	65.4
Bulgaria	213.0	103.8		353.0	20.2	15.0		18.8		118.2	7.7	8.5	0.4	0.4	705.9	1115.5
Croatia	57.4	32.8		299.6	23.1		15.2	14.2		17.8		1.3	50.8	26.1	29.7	167.6
Czech Republic	454.3	16.2		106.0	52.2	2.0		29.0	7.0	347.2		32.8	7.4	55.5	29.5	820.3
Denmark	632.9				64.9			40.1	1.6	159.5		40.1		38.9		710.5
Estonia	129.6				32.2			9.9	0.0	80.6		14.5				110.0
Faroe Islands								0.1								
Finland	515.9				329.6			26.3		98.5		24.3		16.2		215.5
France	1696.0	815.5	22.0	1573.7	101.2	7.2	17.8	162.2	2.0	1490.8	21.1	27.2	39.0	378.7	658.5	5480.4
Germany	1838.8	99.7		456.8	164.7			264.4	4.1	1434.8		657.9	1.0	379.7	25.2	3182.0
Greece	117.4	101.4		214.0	62.1		816.4	36.4	1.7	4.7	29.2	18.6	2.0	17.5	28.4	652.6
Hungary	301.1	75.3	28.3	1162.0	56.3	11.5		22.8	0.2	228.0	2.5	38.7	34.6	23.4	535.5	1074.6
Iceland								0.7								
Ireland	178.5				21.0			11.8		7.8		0.2		0.6		89.8
Italy	309.2	776.8		998.2	139.6		1172.5	67.9		14.5	235.9	4.1	146.0	70.7	121.3	1949.0
Latvia	122.0				61.1	1.8		35.5		98.3		46.9		2.6		264.8
Lithuania	309.9			6.2	62.3	3.1		46.7	9.2	196.8		61.5		15.4		445.1
Luxembourg	9.0	1.3		0.3	1.3			0.6	0.0	4.9		1.1				13.6
Malta	0.5	1.7					0.0	1.0								2.8
Montenegro	0.8	9.8		2.7	0.2		2.5	10.4				0.2				0.8
Netherlands	41.9	0.2		18.9	1.6			156.0	0.0	2.7		2.1		75.6		148.9
Norway	142.2		0.1		75.4			13.7		5.5		6.8				82.9
Poland	1158.9		1.7	291.1	547.1	25.5		515.8	58.8	796.3		1262.5	0.2	217.8	3.1	2262.8
Portugal	34.4	190.9		96.9	54.2		350.8	33.8			27.9	20.9		1.6	17.9	71.5
Rep. of Moldova	125.0	135.3	0.8	426.2	2.9			31.0		38.9		0.7	49.4	28.9	257.9	333.8
Romania	416.1	181.3		2370.5	195.4			261.8	0.6	349.7	10.3	14.1	86.1	24.9	846.6	2036.8
Russian Fed.	7955.0	43.4		1291.5	3037.4	15.9		2400.9	91.0	601.5	176.5	1814.8	875.1	940.1	5886.6	24288.0
Serbia	89.5	56.2	1.0	1222.7	37.2			80.0		13.4		5.4	154.6	63.7	171.7	521.9
Slovakia	178.7	10.1	2.0	163.6	17.3	1.3		13.9	1.2	152.2		18.2	10.9	18.3	83.8	362.9
Slovenia	18.5	16.2		40.0	2.0		0.9	4.7	0.1	4.5		0.8	0.1	1.1	0.2	32.6
Spain	3084.8	1079.6		350.9	524.2		2424.0	82.4	18.9	18.1	111.3	120.8	0.6	57.5	727.0	1909.8
Sweden	336.2				190.9			27.5		95.9		27.0		39.9		378.7
Switzerland	32.2	14.9	0.2	16.8	2.0	0.0		11.4		20.8		2.0	1.1	19.6	4.2	91.0
The Rep. Macedonia	45.9	21.3	0.0	31.1	2.6		5.4	13.5	0.1	0.7	3.2	3.8	0.3	0.4	4.3	86.4
Ukraine	4414.4	70.9	0.5	2390.6	375.0	12.8		1431.7	10.9	879.2	24.1	362.5	767.6	511.6	4173.0	6368.4
United Kingdom	974.3	0.7			124.5			142.2	119.1	628.5		6.0		120.1		1904.7
TOT. E.U	26873	3914	57	14473	6632	119	4844	6551	330	8229	650	5150	2259	3357	14352	58344

Table 8. Cropping systems land use at country level (average on 2006-2011)[v].

COUNTRY	LAND USE (1000 Ha)								
	Cereals	**Coarse Grain**	**Fibre Crops Primary**	**Fruit (excl. Melons)**	**Oilcrops Primary**	**Pulses**	**Roots and Tubers**	**Treenuts**	**Vegetables Primary**
Albania	145.3	69.5	0.8	47.2	40.8	21.9	9.3	6.3	33.2
Austria	823.9	525.5	0.5	70.7	133.4	29.0	22.4	4.8	15.3
Belarus	2399.1	1875.1	65.8	92.3	326.1	125.1	389.0	7.5	82.5
Belgium	328.8	124.7	12.5	20.2	23.1	1.5	72.8	0.2	60.0
Bosnia and Herz.	304.9	239.5	0.0	115.5	5.9	13.8	38.7	4.5	132.3
Bulgaria	1730.8	607.6	0.7	168.3	853.7	7.6	18.8	8.7	37.0
Croatia	555.2	387.5	0.0	74.1	115.3	3.3	14.2	8.3	14.6
Czech Republic	1526.9	706.6	0.7	40.1	469.1	30.6	29.0	1.6	12.4
Denmark	1489.6	779.1	0.0	6.9	159.6	7.6	40.1	0.0	10.1
Estonia	295.1	185.0	0.1	8.1	80.7	6.0	9.9	0.0	3.1
Faroe Islands	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Finland	1103.9	888.4	0.0	7.0	98.5	4.5	26.3	0.0	9.1
France	9404.7	3903.2	65.9	940.9	2304.7	294.2	162.2	28.2	252.7
Germany	6719.7	3537.6	0.4	179.1	1479.0	103.7	264.4	5.2	111.8
Greece	1095.7	413.9	294.5	255.5	1148.4	25.0	36.6	41.0	117.8
Hungary	2778.6	1701.5	0.3	158.6	824.1	21.2	22.8	4.4	82.5
Iceland	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.1
Ireland	292.7	202.8	0.0	2.6	7.8	3.5	11.8	0.0	5.6
Italy	3690.8	1505.9	3.0	1266.3	1457.5	84.4	68.5	181.7	536.3
Latvia	525.5	260.7	0.3	8.4	100.8	2.1	35.5	0.0	11.4
Lithuania	1028.1	583.0	0.6	23.8	199.9	43.9	46.7	0.0	15.7
Luxembourg	29.6	16.0	0.0	2.3	4.9	0.4	0.6	0.0	0.0
Malta	3.3	0.5	0.0	2.3	0.0	0.6	1.0	0.0	5.1
Montenegro	4.8	4.0	0.0	16.8	2.5	1.1	10.3	0.4	6.7
Netherlands	216.4	67.6	3.2	21.5	6.1	2.7	156.0	0.0	85.7
Norway	307.4	224.4	0.0	4.5	5.5	1.4	13.7	0.0	6.9
Poland	8229.6	5966.8	1.8	394.6	827.1	136.4	515.8	23.2	204.0
Portugal	326.8	227.4	0.0	365.8	368.7	31.2	36.7	69.4	86.5
Rep. of Moldova	892.6	558.8	0.0	229.2	346.3	33.7	31.0	5.1	47.7
Romania	5087.2	3040.1	1.7	337.8	1296.4	57.5	261.8	1.7	264.7
Russian Fed.	40039.3	15574.7	77.8	564.4	7613.4	1077.8	2400.9	14.1	788.2
Serbia	1916.8	1394.9	0.0	369.4	340.4	48.2	80.0	14.7	157.3
Slovakia	755.0	392.1	0.0	28.0	254.6	12.0	13.9	1.2	28.0
Slovenia	99.5	66.9	0.0	22.7	5.7	1.7	5.6	0.3	3.9
Spain	6181.9	4160.9	61.7	1695.9	3243.9	317.4	84.3	606.3	355.4
Sweden	998.6	619.9	0.0	9.9	105.9	17.5	27.5	0.0	21.7
Switzerland	154.5	63.4	0.0	22.6	26.2	4.5	11.4	1.5	14.6
The Rep. Macedonia	173.1	83.5	0.0	46.8	11.1	16.8	13.5	6.1	46.0
Ukraine	14387.2	7994.7	7.3	292.7	5952.6	340.4	1431.7	14.2	551.1
United Kingdom	3030.3	1125.6	10.7	29.1	657.3	187.5	142.2	0.0	113.3
TOT. E.U	119073	60079	610	7942	30897	3118	6558	1061	4330

Table 9. Crop harvested areas for the 4 FAO European areas (average on 2006-2011)[vi].

EUROPE AREA	AREA HARVESTED (1000 Ha)															
	Barley	**Grapes**	**Green Maize**	**Maize**	**Oats**	**Oilseeds**	**Olives**	**Potatoes**	**Pulses**	**Rapeseed**	**Rice paddy**	**Rye**	**Soybeans**	**Sugar beet**	**Sunflower**	**Wheat**
Northern Europe	3341.3	0.7	0.1	6.2	962.0	4.9	0.0	354.4	129.9	1371.4	0.0	227.2	0.0	233.6	0.0	4202.1
Southern Europe	3781.5	2300.1	1.1	3504.2	871.9	0.0	4826.0	392.2	21.8	74.6	407.5	180.8	359.3	240.6	1102.3	5536.2
Western Europe	3878.4	976.0	22.8	2299.7	304.2	30.2	17.8	689.8	8.6	3016.2	21.1	735.3	67.9	966.0	715.5	9418.5
Eastern Europe	15871.7	637.5	33.3	8662.7	4493.8	84.0	0.0	5114.7	170.0	3766.6	221.2	4006.8	1831.6	1916.5	12534.5	39187.0
TOT. E.U	26873	3914	57	14473	6632	119	4844	6551	330	8229	650	5150	2259	3357	14352	58344

Table 10. Cropping systems land use for the 4 FAO European areas (average on 2006-2011).

EUROPE AREA	LAND USE (1000 Ha)								
	Cereals	**Coarse Grain**	**Fibre Crops Primary**	**Fruit (excl. Melons)**	**Oilcrops Primary**	**Pulses**	**Roots and Tubers**	**Treenuts**	**Vegetables Primary**
Northern Europe	14498.0	8554.3	360.0	4278.2	6740.2	565.6	398.8	939.0	1495.1
Southern Europe	17677.6	8238.0	82.6	1257.4	3977.4	436.1	689.8	40.0	540.1
Western Europe	77826.3	38418.1	156.0	2306.1	18763.5	1842.3	5114.7	81.6	2098.1
Eastern Europe	9071.1	4869.0	11.7	100.3	1416.0	274.0	354.4	0.0	196.9
TOT.E.U	119073	60079	610	7942	30897	3118	6558	1061	4330

Table 11. Crop harvested areas for regions defined by the EEA biogeographic classification (average on 2006-2011)[vii].

BIOGEO.CLASS	AREA HARVESTED (1000 Ha)															
	Barley	**Grapes**	**Green Maize**	**Maize**	**Oats**	**Oilseeds**	**Olives**	**Potatoes**	**Pulses**	**Rapeseed**	**Rice paddy**	**Rye**	**Soybeans**	**Sugar beet**	**Sunflower**	**Wheat**
Atlantic	3595.0	2189.5	0.0	1746.6	796.2	0.0	4809.9	254.6	21.8	38.0	407.5	169.8	149.3	149.7	900.3	4748.6
Continental	386.2	59.3	0.9	186.2	105.9	23.0	0.0	47.5	2.5	78.3	0.0	53.3	28.0	63.0	31.7	472.4
Mediterranean	2068.9	1.3	0.0	114.5	866.3	4.9	0.0	535.5	9.4	825.3	0.0	628.1	0.0	169.6	12.5	1938.2
Boreal	3572.1	816.5	22.0	1656.4	318.2	7.2	17.8	585.0	122.7	2299.5	21.1	76.1	39.0	682.9	658.5	8538.4
Alpine	17250.7	847.8	34.4	10769.1	4545.4	84.0	16.1	5128.3	173.9	4987.6	221.2	4222.9	2042.7	2291.4	12749.2	42646.1
TOT. E.U	26873	3914	57	14473	6632	119	4844	6551	330	8229	650	5150	2259	3357	14352	58344

Table 12. Cropping systems Land use for regions defined by the EEA biogeographic classification (average on 2006-2011).

BIOGEO.CLASS	LAND USE (1000 Ha)								
	Cereals	**Coarse Grain**	**Fibre Crops Primary**	**Fruit (excl. Melons)**	**Oilcrops Primary**	**Pulses**	**Roots and Tubers**	**Treenuts**	**Vegetables Primary**
Atlantic	11621.6	6465.5	360.0	3696.6	6272.9	498.5	260.3	911.2	1186.9
Continental	1285.8	813.4	0.5	97.9	165.0	34.9	47.5	6.4	36.8
Mediterranean	6350.3	4412.1	66.8	149.5	912.0	199.1	535.6	7.5	143.5
Boreal	14762.5	6203.0	92.4	1021.2	3158.6	497.1	585.0	28.4	527.3
Alpine	85052.8	42185.5	90.7	2976.9	20388.6	1888.5	5129.3	107.1	2435.6
TOT.E.U	119073	60079	610	7942	30897	3118	6558	1061	4330

Table 13. List of the models available within the CropM (aggregated by Partner)

Partner name	Model acronym	Simulted crops or cropping systems
Norwegian Institute of Agricultural and Environmental Research, Bioforsk	LINGRA/BASGRA	timothy, perennial rygrass
	CATIMO	timothy
	ENGNOR	timothy
	FROSTOL	winter wheat, (forage grasses)
	KONOR	small grain spring cereals
Leibniz-Zentrum fuer Agrarlandschaftsforschung (ZALF) e.V.	HERMES	wheat, barley, rye, maize, oilseed rape, sugar beet (generic)
	N-VINO	grapevine
	MONICA	wheat, barley, rye, triticale, maize, oilseed rape, sugar beet, sorghum, pea (generic)
Scottish Agricultural College	DNDC	generic
	Ndicea	generic
	SPACSYS	Wheat, barley, oats, pea, bean, rye grass, oilseed rape
	COUP	Wheat, barley, oats, pea, bean, rye grass, oilseed rape
Wagenigen University and Research Centre	LINGRA	perennial ryegrass
	LINTUL4	main crop types in Europe
	LINTUL5	main crop types in Europe
	LINTUL6	main crop types in Europe
	WOFOST	main crop types in Europe
	LINPAC	annual crops: wheat, maize, sorghum, millet; perennial crops: miscanthus, reed canary grass, willow, Eucalyptus
	CNGRAS	perennial ryegrass
	Rotask 1.0	main crop types (in rotation) in Europe
	PlantSys 1.5	main crop types (in rotation)
University of Sassari	DSSAT	winter durum wheat, tomato
	DNDC	winter durum wheat
	Agricultural Policy/Environmental eXtender Model (APEX) (Version 0604)	about 100 different crops; the model is also capable of simulating or perennial crops mixed plant stands
	CROPSYST	several crops not yet defined (grapevine, wheat, barley, maize)
	SiriusQuality	winter and spring bread wheat, durum wheat
	Crop models on grapevine and olive	grapevine and olive
	DSSAT	winter wheat, maize

(cont.)

Partner name	Model acronym	Simulted crops or cropping systems
University of Sassari	Stamina/ARMOSA	cropping systems including Mais wheat, Barley Lucerne, Sorghum, rape oilseed, sunflower
	SALUS- Systems Approach for Land Use Sustainability	Durum Wheat, Soft Wheat, Maize irrigated and rainfed, Rice, Cover Crops
	EPIC	Cropping systems including maize, italian ryegrass
	DSSAT	Cropping systems including wheat, rapeseed, maize
Institute of Soil Science and Plant Cultivation-State Research Institute Pulawy, Poland	DNDC	main crop types (in rotation)
Technical University of Madrid	CERES MAIZE	maize
	CSM-IXIM	maize
	CERES WHEAT	wheat
	CERES BARLEY	barley
	STICS	grapevine
	CROPSYST	several crops not yet defined (grapevine, wheat, barley, maize)
	AQUACROP	sunflower, maize, wheat
	Villalobos et al model	olive
	DNDC	barley, maize,
INRA	STICS - Simulateur multidisciplinaire pour les cultures standard and SUNFLO	Durum Wheat, Tender Wheat, Maize irrigated and rainfed, Rice? (Ruget), eventually Sunflower, Colza, Pea.
	SiriusQuality	winter and spring bread wheat, durum wheat
Swedish University of Agricultural Sciences, and, Lund University	FOPROQ	Grass and clover leys
	QUAL	Grass and clover leys
	SOIL/SOILN Matlab/Simulink simplified version	Grass and clover leys
	MAISPROQ	Fodder maize
	CoupModel (SOIL/SOILN)	Catch crop; Perennial rye grass; winter wheat; cereal crop sequences; willow
	SOILNdb	Crop rotations (leys, cereals, legumes etc.)
	FOPROQ; Temp index	Winter wheat
	Radiation Use Efficiency model	Willow

(cont.)

Partner name	Model acronym	Simulted crops or cropping systems
Lund University	LPJ-GUESS	temperate cereals, rice, maize, millet, sorghum, pulses, sugar beet, cassava, sunflower, soybean, groundnuts, rape seed, C3 and C4 grass. Fallow, reforestation, and irrigation as available management.
Global Change Research Centre, Academy of Sciences of the Czech Republic	DSSAT	winter wheat, spring barley
	HERMES	wheat, barley, maize, oilseed rape, sugar beet (generic), grassland (experimental)
	DAISY, WOFOST, STICS	wheat, barley, oil seed rape
Copenhagen University	AFRC2, Daisy, SIRIUS	Arable crops, pasture
MTT Agrifood Research Finland, Mikkeli, Agrosystems Modelling Group	WOFOST 7.1 (re-calibrated for FIN crops); DAISY 4.01 and APSIM 7.4	spring barley, turnip rape, winter wheat (Finnish cultivars) - and other major crop types in EU with default values
Aarhus University	Daisy	Winter wheat
	FASSET	Winter wheat
	FASSET	Arable crop rotations: S. barley, winter wheat, winter oilseed rape, grain maize, cover crops
	Daisy	Arable crop rotations: S. barley, winter wheat, winter oilseed rape
	FASSET	Spring barley, cover crop
IBG-3	SOILCO2/RothC/SUCROS	winter wheat
Rothamsted Research	Sirius	wheat (spring, winter)
University of Bonn	SIMPLACE (APES,ACE)	Crop rotations and single crops: Wheat, Barley,Oilseed rape, maize,sugar beets
University of Bonn Ulg - Gembloux Agro-Bio Tech	EPIC	Cropping systems/rotations: Maize, Wheat, Barley,pasture,oil seed rape, potatos, sugar beet,rye,oat
	STICS	Winter wheat -
University of Natural Resources and Life Sciences, Vienna (BOKU)	EPIC	all major food, feed, and bio-energy crops, grassland
Karlsruhe Institute of Technology	LandscapeDNDC	arable crops, grassland, forest
Rothamsted Research	SPACSYS	Wheat, barley, oats, pea, bean, rye grass, oilseed rape
Université de Liège – Arlon Campus Environnmenent	WOFOST, B-CGMS	winter wheat, winter barley, fodder maize, winter rape seed, potatoes, sugar beet and permanent meadow
Aberdeen University	DayCent	generic
Aberdeen University Potsdam Institute for Climate Impact Reserach	ECOSSE	Arable crops especially on organic soils
	SWIM/EPIC	crop rotations, crops
Potsdam Institute for Climate Impact Reserach	LPJmL	wheat, rice, maize, millet, pulses, sugar beet, cassava, soybean, groundnut, sunflower, rapeseed, sugarcane

Table 14. List of the models available within the CropM (aggregated by Model)

Model acronym	Partner providers	Partner Name			
AFRC2	1	Copenhagen University			
APEX (Version 0604)	1	University of Sassari			
AQUACROP	1	Technical University of Madrid			
ARMOSA	1	University of Sassari			
CATIMO	1	Norwegian Institute of Agricultural and Environmental Research, Bioforsk			
CERES BARLEY	1	Technical University of Madrid			
CERES MAIZE	1	Technical University of Madrid			
CERES WHEAT	1	Technical University of Madrid			
CNGRAS	1	Wagenigen University and Research Centre			
COUP	1	Scottish Agricultural College			
CoupModel (SOIL/SOILN)	1	Swedish University of Agricultural Sciences, and, Lund University			
Crop models on grapevine and olive	1	University of Sassari			
CROPSYST	2	University of Sassari			
CROPSYST	1	Technical University of Madrid			
CSM-IXIM	1	Technical University of Madrid			
DAISY	3	Global Change Research Centre, Academy of Sciences of the Czech Republic	Copenhagen University	Aarhus University	
DayCent	1	Aberdeen University			
DNDC	4	Scottish Agricultural College	University of Sassari	Institute of Soil Science and Plant Cultivation-State Research Institute Pulawy, Poland	Technical University of Madrid
DSSAT	2	University of Sassari	Global Change Research Centre, Academy of Sciences of the Czech Republic		
ECOSSE	1	Aberdeen University			
ENGNOR	1	Norwegian Institute of Agricultural and Environmental Research, Bioforsk			

(cont.)

Model acronym	Partner providers	Partner Name			
EPIC	3	University of Sassari	University of Bonn	University of Natural Resources and Life Sciences, Vienna (BOKU)	
FASSET	1	Aarhus University			
FOPROQ	1	Swedish University of Agricultural Sciences, and, Lund University			
FROSTOL	1	Norwegian Institute of Agricultural and Environmental Research, Bioforsk			
HERMES	2	eibniz-Zentrum fuer Agrarlandschaftsforschung (ZALF) e.V.	Global Change Research Centre, Academy of Sciences of the Czech Republic		
KONOR	1	Norwegian Institute of Agricultural and Environmental Research, Bioforsk			
LandscapeDNDC	1	Karlsruhe Institute of Technology			
LINGRA	2	Wagenigen University and Research Centre	Norwegian Institute of Agricultural and Environmental Research, Bioforsk		
LINPAC	1	Wagenigen University and Research Centre			
LINTUL4	1	Wagenigen University and Research Centre			
LINTUL5	1	Wagenigen University and Research Centre			
LINTUL6	1	Wagenigen University and Research Centre			
LPJ-GUESS	1	Lund University			
LPJmL	1	Potsdam Institute for Climate Impact Reserach			
MAISPROQ	1	Swedish University of Agricultural Sciences, and, Lund University			
MONICA	1	(ZALF) e.V.			
Ndicea	1	Scottish Agricultural College			
N-VINO	1	(ZALF) e.V.			
PlantSys 1.5	1	Wagenigen University and Research Centre			
QUAL	1	Swedish University of Agricultural Sciences, and, Lund University			

(cont.)

Model acronym	Partner providers	Partner Name			
Radiation Use Efficiency model	1	Swedish University of Agricultural Sciences, and, Lund University			
Rotask 1.0	1	Wagenigen University and Research Centre			
SALUS	1	University of Sassari			
SIMPLACE (APES,ACE)	1	University of Bonn			
SIRIUS	2	Copenhagen University	Rothamsted Research		
SiriusQuality	2	University of Sassari	INRA		
SOIL/SOILN Matlab/Simulink simplified version	1	Swedish University of Agricultural Sciences, and, Lund University			
SOILCO2/RothC/SUCROS	1	IBG-3			
SOILNdb	1	Swedish University of Agricultural Sciences, and, Lund University			
SPACSYS	2	Scottish Agricultural College	Rothamsted Research		
Stamina	1	University of Sassari			
STICS	8	Technical University of Madrid	Global Change Research Centre, Academy of Sciences of the Czech Republic	Ulg - Gembloux Agro-Bio Tech	INRA
SWIM/EPIC	1	Potsdam Institute for Climate Impact Reserach			
Villalobos et al model	1	Technical University of Madrid			
WOFOST	2	Wagenigen University and Research Centre	Global Change Research Centre, Academy of Sciences of the Czech Republic		
WOFOST 7.1 (re-calibrated for FIN crops)	1	MTT Agrifood Research Finland, Mikkeli, Agrosystems Modelling Group			
WOFOST, B-CGMS	1	Université de Liège – Arlon Campus Environnmenent			

[i] All the data reported from Table 1 to Table 6 were collected from Eurostat database

[ii] European areas (Tables 3-4) were create according to FAO database (FAOSTAT)

[iii] European Environmental Agency Biogeographic regions consist in: Atlantic (Belgium, Denmark, France, Ireland, Netherlands, United Kingdom); Continental (Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Luxembourg, Poland, Romania, Slovakia, Slovenia); Mediterranean (Cyprus, Greece, Italy, Macedonia, Malta, Portugal, Spain); Boreal (Estonia, Finland, Latvia, Lithuania, Sweden) ; Alpine (Austria, Norway); Anatolian (Turkey); Artic (Iceland).

[iv] All the data reported from Table 7 to Table 12 were collected from FAOSTAT database

[v] **Cereals (**Barley, Buckwheat, Cereals-nes, Maize, Millet, Mixed grain, Oats, Rice, paddy, Rye, Sorghum, Triticale, Wheat**); Coarse Grain** (Barley, Buckwheat, Cereals-nes, Maize, Millet, Mixed grain, Oats, Rye, Sorghum, Triticale); **Fibre Crops Primary** (Flax fibre and tow, Hemp Tow Waste, Other Bastfibres, Seed cotton); **Fruit (excl. Melons)** (Apples, Apricots, Avocados, Bananas, Berries, Blueberries, Carobs, Cherries, Citrus fruit, Cranberries, Currants, Dates, Figs, Fruit Fresh, Fruit, tropical fresh, Gooseberries, Grapefruit (inc. pomelos), Grapes, Kiwi, Lemons and limes, Oranges, Peaches and nectarines, Pears, Persimmons, Pineapples, Plums and sloes, Quinces, Raspberries, Sour cherries, Stone fruit, Strawberries, Tangerines, mandarins, clem.); **Oilcrops Primary** (Castor oil seed, Groundnuts, Hempseed, Linseed, Melonseed, Mustard, Oilseeds, Olives, Poppy seed, Rapeseed, Safflower seed, Seed cotton, Sesame seed, Soybeans, Sunflower seed); **Pulses** (Beans, dry, Broad beans, horse beans, dry, Chick peas, Cow peas, dry Lentils, Lupins, Peas, dry, Pulses, nes, Vetches); **Roots and Tubers** (Potatoes, Roots and Tubers, nes, Sweet potatoes, Taro (cocoyam), Yams); **Treenuts** (Almonds, with shel, Chestnuts, Hazelnuts, with shell, Nuts, nes, Pistachios, Walnuts, with shell); **Vegetables Primary** (Artichokes, Asparagus, Beans, green, Cabbages and other brassicas, Carrots and turnips, Cauliflowers and broccoli, Chillies and peppers, green, Cucumbers and gherkins, Eggplants (aubergines), Garlic, Leeks, other alliaceous veg, Leguminous vegetables, nes, Lettuce and chicory, Maize, green, Mushrooms and truffles, Okra, Onions (inc. shallots), green, Onions, dry, Other melons (inc.cantaloupes), Peas, green, Pumpkins, squash and gourds, Spinach, String beans, Tomatoes, Vegetables fresh nes, Watermelons)**.**

[vi] European areas (Tables 3-4, 9-10) were create according to FAO database (FAOSTAT)

[vii] European Environmental Agency Biogeographic regions consist in: Atlantic (Belgium, Denmark, France, Ireland, Netherlands, United Kingdom); Continental (Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Luxembourg, Poland, Romania, Slovakia, Slovenia); Mediterranean (Cyprus, Greece, Italy, Macedonia, Malta, Portugal, Spain); Boreal (Estonia, Finland, Latvia, Lithuania, Sweden) ; Alpine (Austria, Norway); Anatolian (Turkey); Artic (Iceland).